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(54) **Method for the control of an elevator group.**

(57) Method for controlling an elevator group, in which statistical data on the passenger traffic within the elevator group, covering the times and local and total volumes of the traffic, and a number of different traffic types used in the group control are stored in a memory unit belonging to the control system. According to the invention, the traffic situation is divided into two or more traffic components, the relative proportions of different traffic components and the prevailing traffic intensity are deduced from the traffic statistics, the traffic components and traffic intensity, i.e. the traffic factors, are subjected to assumptions whose validity is described by means of membership functions of the factors, a set of rules corresponding to different traffic types are formed from these factors, the rules are assigned values by means of the factors and membership functions, the one of the rules which best describes the prevailing traffic is selected, and the traffic type corresponding to the selected rule is used in the control of the elevator group.

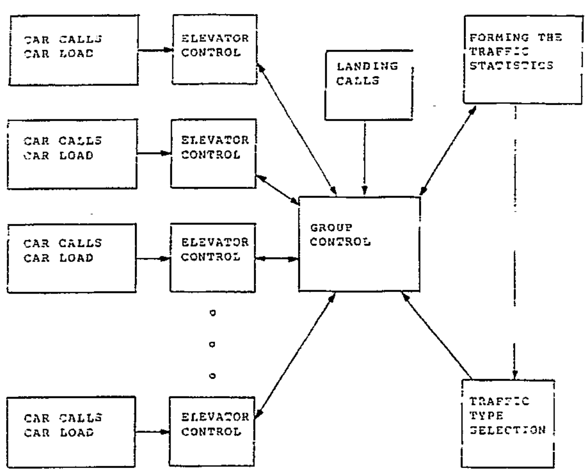

Fig.1

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METHOD FOR THE CONTROL OF AN ELEVATOR GROUP

The present invention relates to a method for the control of an elevator group as defined in claim 1.

The problem at the background of the invention is associated with the detection of a peak passenger traffic condition on the main entrance floor or elsewhere. In conventional group control, a peak traffic condition is detected on the basis of the number of departures of elevators with a full load and of the numbers of calls. However, this data is often obtained at a stage when the peak traffic condition has continued for some time or is already over.

In earlier group control systems, the problem is solved on the basis of the numbers of car calls, landing calls and the car load data. For example, if the number of car calls issued from the main entrance floor exceeds a given limit and the cars departing from there are fully loaded, the situation is interpreted as an up peak traffic condition. Similarly, if the number of down-calls exceeds a certain limit and simultaneously the incoming traffic is low and the number of up-calls is low in comparison, then the situation is recognized as a down peak traffic condition.

Patent publication GB-2129971 proposes a control method in which the characteristic traffic modes are formed daily on the basis of the passenger traffic flow data, from which the future traffic is predicted. The characteristic traffic modes are classified on the basis of the volume of upward and downward passenger traffic and the distribution of the traffic between different floors. The traffic modes learn typical data to be used in the elevator control, e.g. door operation times, probabilities of stopping of the cars, load limitations in upward and downward traffic, energy-saving load, etc. Statistics on the traffic modes are updated daily according to the times of the day and for different types of day. However, the amount of data to be stored is very large and the method is suitable only for that specific environment, not for common group control strategies.

The object of the present invention is to eliminate the drawbacks referred to. A specific object of the invention is to produce an elevator group control method whereby a control mode suited to the prevailing passenger traffic type is determined in advance, mainly on the basis of statistical data.

In the method of the invention for controlling an elevator group, statistical traffic data for the elevator group, covering the local and total traffic volumes at different times, and a number of different traffic type definitions are stored in a memory unit of the control system. In the method of the invention, the traffic situation is divided into two or more, preferably three traffic components: incoming, outgoing and inter-floor traffic.

"Incoming traffic" refers to the traffic consisting of passengers travelling from one or several entrance floors of the building to other floors. Similarly, "outgoing traffic" refers to the traffic consisting of passengers travelling from the other floors to the entrance floors of the building. All the rest of the passenger traffic in the building belongs to the third category, i.e. inter-floor traffic.

To select the traffic type in concern for the group control, the relative proportions of different traffic components and the prevailing traffic intensity are deduced from the passenger traffic statistics. Next, the traffic components and traffic intensity, i.e. the traffic factors, are subjected to assumptions whose validity is described by means of membership functions. From these functions, rules describing different traffic types are formed. The values of the membership functions for different factors are determined, whereupon the one of the rules which best describes the prevailing passenger traffic situation is selected. The traffic type corresponding to the selected rule is then used in the control of the elevator group.

In a preferable solution, the traffic statistics are kept up-to-date by continuously updating the data base with current traffic data. The saving of data can be performed separately for different days of the week and for certain intervals, e.g. at an accuracy of 15 minutes or half an hour. Usually the statistics representing the local and total volumes of passenger traffic are based on the information obtained from the car load weighing devices, photocell signals and from the call buttons. The number of people leaving an elevator and of people entering an elevator on a given floor is preferably calculated from the changes of car load data during the stop at the floor.

The values of the membership functions preferably vary between (0,1). A zero value of the function means that the assumption is completely invalid, while the value 1 means that the assumption is completely valid. Intermediate values between 0 and 1 describe the degree of validity of the assumption.

The traffic type is selected by choosing the one of the rules consisting of a combination of assumptions which best describes the prevailing traffic situation. The values for the rules consisting of the membership functions are calculated according to fuzzy logic using logical "AND" and "OR" operators of the Zadeh extension prinicple, where the operators are based on the min-max method. In the rules, the factors are compared using the AND operator, and the OR operator is used to select the most advantageous rule.

Thus, preferably the one of the rules is selected whose smallest membership function has the highest value.

On the basis of the statistics, the probable times of beginning and end of traffic peaks can be fairly accurately predicted, at least in office-type buildings. As no accurate data regarding traffic peaks is obtained from the elevators in advance, the forecast obtained on the basis of statistics facilitates the advance recognition of a peak traffic condition. In the method of the invention, the switch-over from one traffic type to another is effected by making comparisons between the probabilities of the inaccurate data obtained from the elevators and selecting the most probable traffic type. Changes of traffic type will not occur abruptly, because the probability ranges of the factors are quite continuous. In an intermediate region, the probability of a given traffic type increases e.g. in a linear fashion and thus gradually increases the probability of the region within which the traffic type is recognized, thereby preventing abrupt changes from one type to another. The traffic intensity is scaled to the handling capacity of the elevator group, ensuring that the method is suitable for different types of traffic and building and also for situations where, for some reason, one or more elevators are not in bank or are added to the group. Since the method searches for a traffic type which best suits the situation represented by the initial data, a slight inaccuracy in the initial data will have no effect, and even moderately large errors will not result in the recognition of a completely inappropriate traffic type.

The fuzzy-logic principle adopted in the method of the invention is best suited for the definition of uncertain situations, such as the recognition of the traffic type. By employing fuzzy logic, the control strategies change from one traffic type to another more smoothly and no oscillation between the strategies will occur. Fuzzy logic is typically employed in expert systems where the conclusions are based on partial information and on facts stored in a knowledge base.

Moreover, the method of the invention allows new factors, e.g. momentarily explaining ones, to be easily included in the system, because information that is difficult to delimit clearly can be flexibly presented using membership functions. Additional information is easily obtained from detectors, calls, load weighing devices, photocell signals, destination buttons, times of the day, etc. This kind of additional factors can be included in all or some of the rules to be used.

An example is the information obtained from a lobby detector regarding the number of people waiting in the lobby as used to determine the presence of an up peak condition. There may be a large, fair, small or zero number of passengers waiting, which typically can be inferred using fuzzy logic.

In the following, the method of the invention is described in detail, reference being made to the attached drawing, in which

Fig. 1 is a schematic diagram representing the control method of the invention,

Fig. 2 is a block diagram representing the general features of the control method,

Fig. 3 is a block diagram illustrating the selection of traffic type in the method of the invention,

Fig. 4 illustrates the division of the traffic situation into components,

Fig. 5 represents the membership functions of the traffic components, and

Fig. 6 represents the membership functions of the traffic intensity.

As illustrated by Fig. 1, the elevator control systems are connected to the group control board. In practice, the individual elevator control systems and the group control system form an integral whole. Each elevator control system receives the data relating to the car, i.e. car calls and car load. In addition, the group control receives all the landing call data. Based on these data and on other car status data, the traffic statistics are maintained, on the basis of which the traffic type best suited for group control in the prevailing conditions is selected.

Fig. 2 shows a more detailed block diagram of the various stages of the group control procedure. In the memory unit used by the group control in the method of the invention, the traffic statistics are stored separately for each day of the week. Therefore, during group control the memory has to be updated, i.e. it has to know the current day of the week and the time as well as the prevailing operational situation of the elevators, i.e. the numbers of landing calls, the car positions and running directions, the loads of the elevator cars and the car calls. From these data, the control system determines the numbers of people entering and leaving an elevator on each floor in the up direction and the numbers of people entering and leaving an elevator on each floor in the down direction. Statistics on these four floor-specific components and the volume of passenger traffic are continuously updated.

The assumed traffic flow components to be used in the control are mainly determined from the statistics, and the traffic type used by the control system is selected on the basis of the statistics according to the rules of fuzzy logic. The elevator group is then controlled in accordance with the selected traffic type. Different traffic types are utilized in the control using specific peak traffic services, such as delayed departure of cars from the main entrance floor during an up peak. However, the traffic types are mainly brought into effect via differentiated weighting of calls.

The block diagram in Fig. 3 illustrates the principle of selection of traffic type in the method of the invention. First, from the statistics available, the control system deduces the current relative proportions of the traffic components, i.e. incoming, outgoing and inter-floor traffic, as well as the traffic intensity, jointly termed traffic factors. In addition, the intensity is scaled with respect to the up peak handling capacity of the elevator group, i.e. to the maximum number of passengers that can be transported during incoming traffic. In the method, the number of available elevators is always taken into account, so that e.g. when one of the elevators is out of order due to maintenance and the total handling capacity of the group is thus reduced, the relative traffic intensity increases and this is taken into account in controlling the whole group.

Next, from the relative proportions of different traffic components and the normalized traffic intensity known on the basis of the statistics, the values for the membership functions corresponding to the traffic factors are determined. The membership functions are described in greater detail in connection with Figs. 5 and 6. The membership function values are obtained for the various combinations of membership function values, i.e. rules, corresponding to different traffic types, whereupon, based on the values assigned to the various components of the rules, the rule best describing the prevailing passenger traffic situation is selected. Since each rule corresponds to a certain group control strategy, after the selection the elevator group is controlled in accordance with the strategy corresponding to the selected rule.

In the following, the method of the invention for the control of elevator groups is analyzed in detail by referring to Table 1 and Figs. 4-6.

For an elevator group controlled using the method of the invention, the current percentages of the incoming, outgoing and inter-floor traffic components are calculated from the stored statistical traffic data, e.g. as illustrated by Fig. 4. Next, the current statistical traffic intensity is scaled with respect to the currently available handling capacity of the elevator group. After this, the incoming, outgoing and inter- floor traffic components are divided into three subcategories termed LOW, MEDIUM, HIGH, and the intensity is similarly divided into three categories according to its degree, i.e. LIGHT, NORMAL, HEAVY. From these, rules as exemplified by Table 1 are formed.

The group control employs membership functions, i.e. assumptions describing different traffic factors, as illustrated by Figs. 5 and 6. If it is assumed, for example, that the category of traffic intensity is HEAVY (Fig. 6) and if the relative intensity value obtained from the statistics is 0.9, then the membership function has the value of 1, which means that the assumption is completely valid. If the relative intensity value obtained from the statistics is e.g. 0.3, then the value of the membership function is 0 for the assumption HEAVY, because the assumption is completely invalid. If the intensity value is e.g. 0.75, then the value of the membership function is about 0.4, which means that the assumption has some but not a full degree of validity.

It is to be noted that the curves representing membership functions need not necessarily be straight lines between the values 0 and 1. Linearly increasing probabilities of the categories will eliminate drawbacks associated with abrupt divisions between categories. An essential feature of different membership functions is that the membership functions describing the same factor in different categories partially overlap as exemplified by Figs. 5 and 6. This ensures that the transitions from one traffic type to another will not be abrupt and sudden as in currently used control methods.

Next, let us consider rule 4 as an example. Assume that the intensity is 0.7. Since the intensity according to rule 4 is HEAVY, the assumption "intensity HEAVY" is assigned the value of 0.2 from Fig. 6. Our next assumption is that INCOMING is MEDIUM, and according to Fig. 4 INCOMING is 0.6. From Fig. 5, we can see that at the level of 0.6 the assumption has the value of about 0.7. A third assumption is that OUTGOING is LOW, and Fig. 4 shows that the proportion of outgoing traffic is 0.25. Thus, we can see from Fig. 5 that the assumption has the value of 1. A fourth assumption is that INTERFLOOR is LOW, which according to Fig. 4 is 0.15, so that the assumption has the value of 1 as determined from the graph in Fig. 5. Thus, the factors of rule 4 will have the values 0.2, 0.7, 1, 1.

Let us consider two more rules, no. 13 and no. 22, as part of our example. In these rules, the intensity is NORMAL and LIGHT respectively, while the rest of the traffic factors are the same as in rule 4. For rule 13, the value of the first membership function is found to be 0.5, and for rule 22, 0.

After this, the one of the rules which best describes the prevailing traffic situation is selected. Using Zadeh's AND operator, the selection is performed as follows by determining the smallest component of each rule, i.e.

4) min (0.2; 0.7; 1 ; 1) = 0.2
13) min (0.5; 0.7; 1; 1) = 0.5
22) min (0; 0.7; 1; 1) = 0

The preferable one among these three rules is the one whose smallest component has the highest value, i.e. max (0.2; 0.5; 0) = 0.5, which corresponds to rule 13. Therefore, the elevator group would in this case be controlled in accordance with rule 13. In practice, all 27 rules are considered in the manner described, whereupon the first rule whose smallest component has the highest value is selected and subsequently applied in the group control.

TABLE 1

	INTENSITY	INCOMING	OUTGOING	INTERFLOOR	TRAFFIC TYPE
1	HEAVY	HIGH	LOW	LOW	HEAVY UP PEAK
2	HEAVY	LOW	HIGH	LOW	HEAVY DOWN PEAK
3	HEAVY	LOW	LOW	HIGH	HEAVY INTERFLOOR
4	HEAVY	MEDIUM	LOW	LOW	HEAVY INCOMING
5	HEAVY	LOW	MEDIUM	LOW	HEAVY OUTGOING
6	HEAVY	LOW	LOW	MEDIUM	HEAVY INTERFLOOR
7	HEAVY	MEDIUM	MEDIUM	LOW	HEAVY TWO WAY
8	HEAVY	MEDIUM	LOW	MEDIUM	HEAVY MIXED
9	HEAVY	LOW	MEDIUM	MEDIUM	HEAVY MIXED
10	NORMAL	HIGH	LOW	LOW	NORMAL UP PEAK
11	NORMAL	LOW	HIGH	LOW	NORMAL DOWN PEAK
12	NORMAL	LOW	LOW	HIGH	NORMAL INTERFLOOR
13	NORMAL	MEDIUM	LOW	LOW	NORMAL INCOMING
14	NORMAL	LOW	MEDIUM	LOW	NORMAL OUTGOING
15	NORMAL	LOW	LOW	MEDIUM	NORMAL INTERFLOOR
16	NORMAL	MEDIUM	MEDIUM	LOW	NORMAL TWO WAY
17	NORMAL	MEDIUM	LOW	MEDIUM	NORMAL MIXED
18	NORMAL	LOW	MEDIUM	MEDIUM	NORMAL MIXED
19	LIGHT	HIGH	LOW	LOW	LIGHT INCOMING
20	LIGHT	LOW	HIGH	LOW	LIGHT OUTGOING
21	LIGHT	LOW	LOW	HIGH	LIGHT INTERFLOOR
22	LIGHT	MEDIUM	LOW	LOW	LIGHT INCOMING
23	LIGHT	LOW	MEDIUM	LOW	LIGHT OUTCOMING
24	LIGHT	LOW	LOW	MEDIUM	LIGHT INTERFLOOR
25	LIGHT	MEDIUM	MEDIUM	LOW	LIGHT TWO WAY
26	LIGHT	MEDIUM	LOW	MEDIUM	LIGHT MIXED
27	LIGHT	LOW	MEDIUM	MEDIUM	LIGHT MIXED

The selected traffic type mainly affects the weighting of the landing calls. For instance in the case of two-way traffic, more weight is applied to down-calls issued from above the main entrance floor and up-calls issued from the entrance floor. In heavy intensity conditions, the weighting may be e.g. three-fold in relation to other landing calls.

It is to be noted that in the above example the traffic situation is divided into three different components, and these components and the traffic intensity are divided into three subcategories. However, this is only one principle of division which has been found to be a good one, but in the method of the invention these divisions can be made in any manner depending on the requirements in each case.

In the foregoing, the invention has been described in detail by referring to a preferred solution, but different embodiments of the invention are possible within the scope of the idea of the invention as defined in the following claims.

Claims

1. Method for controlling an elevator group, in which statistical data on the traffic within the elevator group, covering the times and local and total volumes of the traffic, and a number of different traffic types used in the group control are stored in a memory unit belonging to the control system, **characterized** in that

- the traffic situation is divided into two or more traffic components,
- the relative proportions of different traffic components and the prevailing traffic intensity are determined on

the basis of the traffic statistics,

- the traffic components and traffic intensity, i.e. the traffic factors, are subjected to assumptions whose validity is described by means of membership functions of the factors,
- rules corresponding to different traffic types are formed from these factors,
- the rules are assigned values from conditions consisting of the factors and membership functions,
- of the rules, the one corresponding to the traffic type best describing the prevailing traffic situation is selected, and
- the traffic type corresponding to the selected rule is used in the control of the elevator group.

2. Method according to claim 1, **characterized** in that the one of the rules whose smallest component has the highest value is selected.

3. Method according to claim 1 or 2, **characterized** in that the traffic situation is divided into three traffic components, i.e. incoming, outgoing and inter-floor traffic, each rule thus comprising four assumptions describing traffic factors.

4. Method according to any one of claims 1 - 3, **characterized** in that the traffic intensity is scaled with respect to the current handling capacity of the elevator group.

5. Method according to any one of claims 1 - 4, **characterized** in that the statistics on the traffic situation are kept up-to-date by continuously updating the data base with data representing the traffic actually taking place, and that the statistics on the local and total volumes of the passenger traffic are based on the data obtained from load weighing devices provided in the elevator cars, and on the call button data and elevator status data.

6. Method according to any one of claims 1 - 5, **characterized** in that the number of people leaving an elevator and people entering an elevator on a given floor is calculated from the car load data during a stop of the elevator at the floor, the numbers of new car calls, photocell signals and hall call or destination call data.

7. Method according to any one of claims 1 - 6, **characterized** in that the traffic intensity is divided into three categories according to its degree: light, normal and heavy.

8. Method according to any one of claims 1 - 7, **characterized** in that the traffic components are divided into three subcategories: low, medium and high.

9. Method according to any one of claims 1 - 8, **characterized** in that one of the factors in the rules consists of the information supplied by a lobby detector regarding the number of people waiting for an elevator.

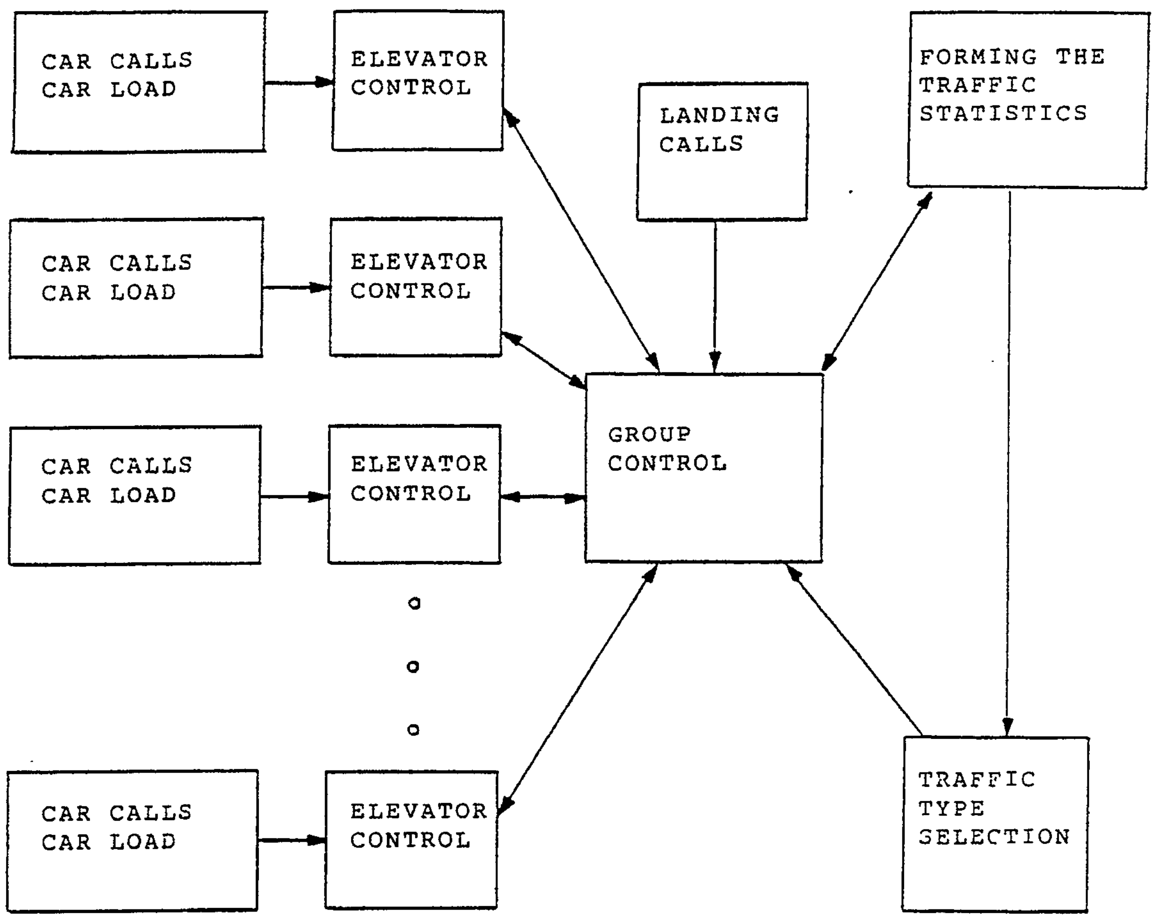
CAR CALLS
CAR LOAD
ELEVATOR CONTROL
CAR CALLS
CAR LOAD
ELEVATOR CONTROL
CAR CALLS
CAR LOAD
ELEVATOR CONTROL
CAR CALLS
CAR LOAD
ELEVATOR CONTROL
LANDING CALLS
FORMING THE TRAFFIC STATISTICS
GROUP CONTROL
TRAFFIC TYPE SELECTION

Fig.1

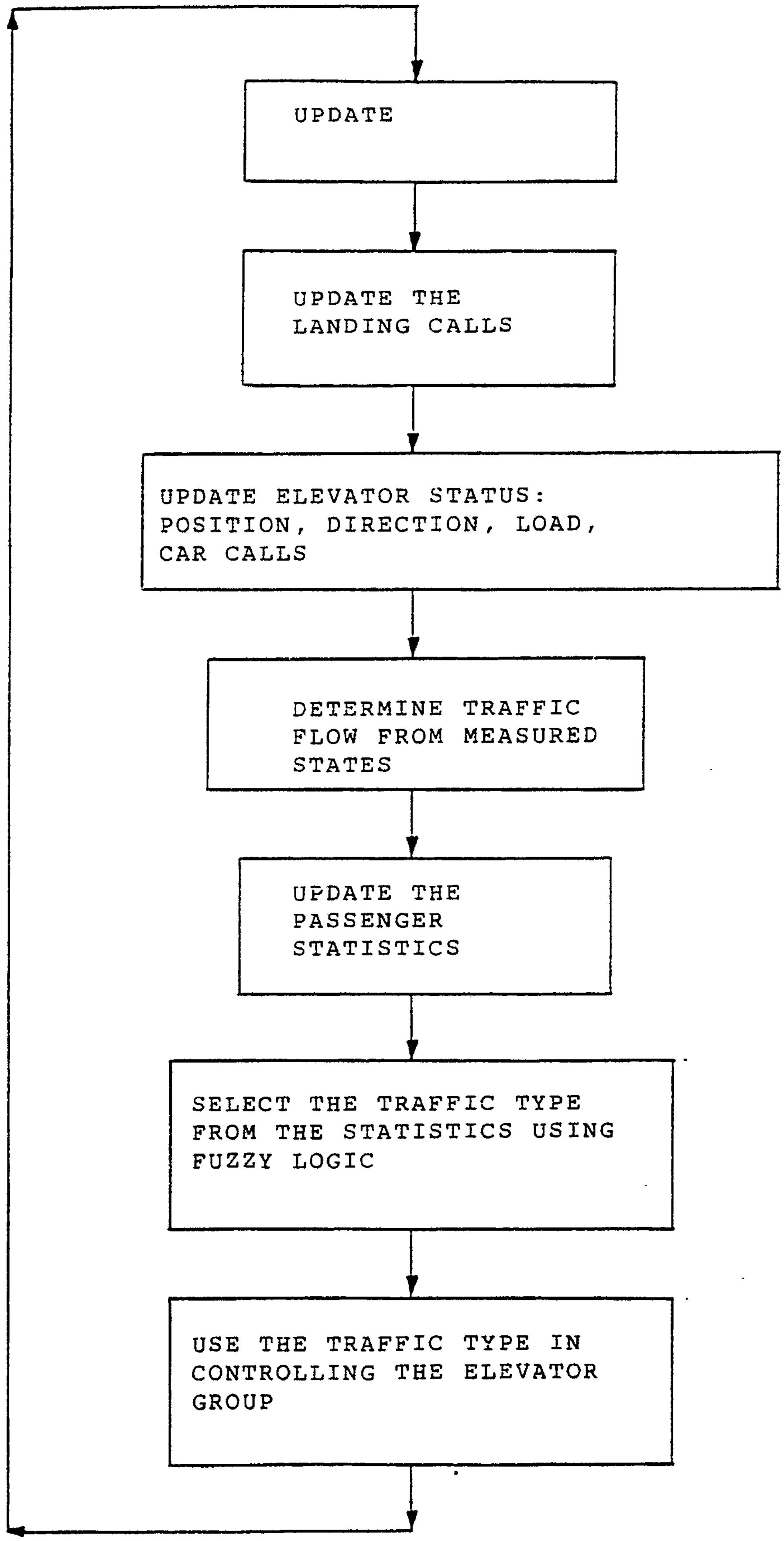
UPDATE
UPDATE THE LANDING CALLS
UPDATE ELEVATOR STATUS: POSITION, DIRECTION, LOAD, CAR CALLS
DETERMINE TRAFFIC FLOW FROM MEASURED STATES
UPDATE THE PASSENGER STATISTICS
SELECT THE TRAFFIC TYPE FROM THE STATISTICS USING FUZZY LOGIC
USE THE TRAFFIC TYPE IN CONTROLLING THE ELEVATOR GROUP

Fig.2

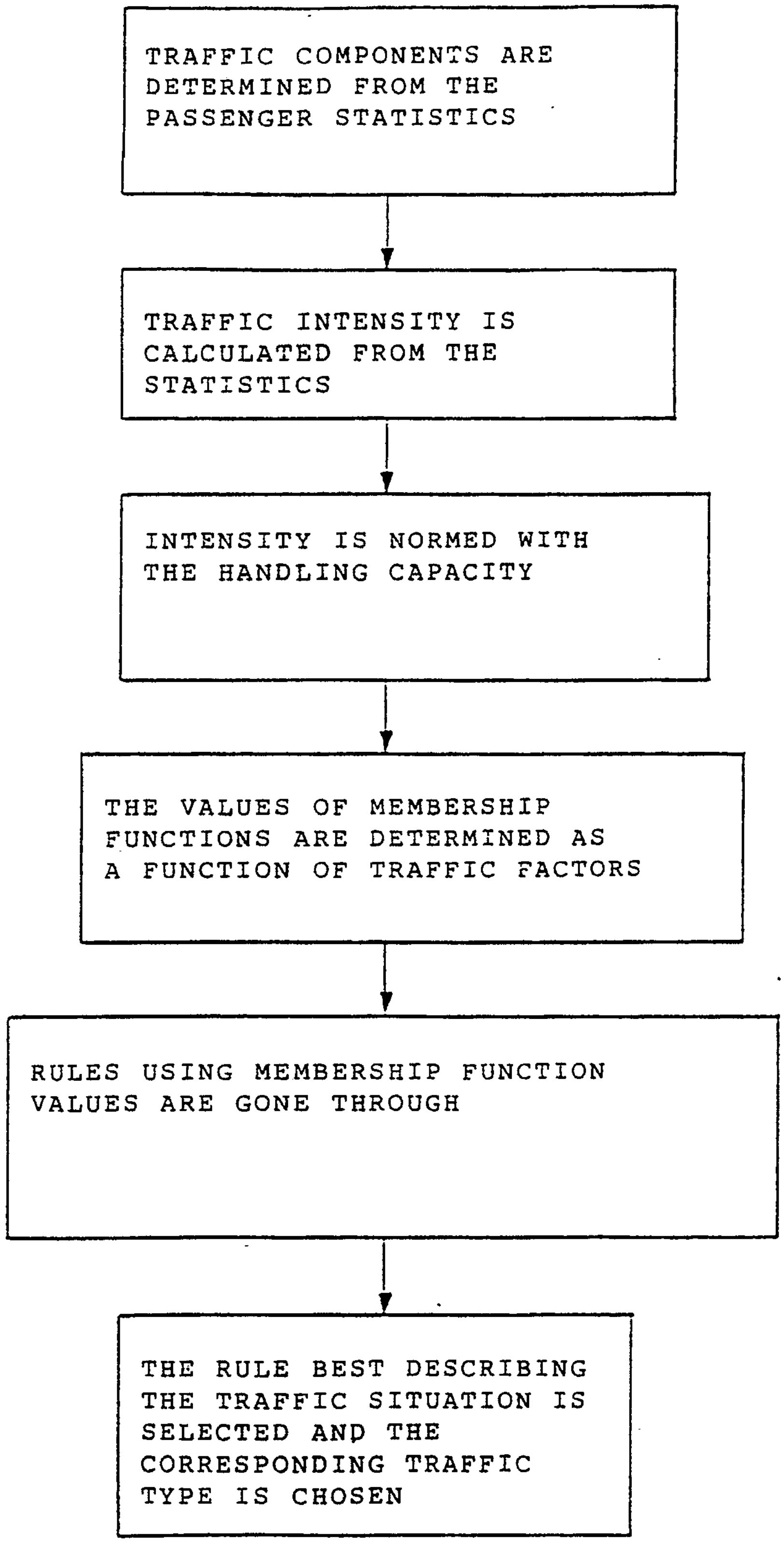
TRAFFIC COMPONENTS ARE DETERMINED FROM THE PASSENGER STATISTICS
TRAFFIC INTENSITY IS CALCULATED FROM THE STATISTICS
INTENSITY IS NORMED WITH THE HANDLING CAPACITY
THE VALUES OF MEMBERSHIP FUNCTIONS ARE DETERMINED AS A FUNCTION OF TRAFFIC FACTORS
RULES USING MEMBERSHIP FUNCTION VALUES ARE GONE THROUGH
THE RULE BEST DESCRIBING THE TRAFFIC SITUATION IS SELECTED AND THE CORRESPONDING TRAFFIC TYPE IS CHOSEN

Fig.3

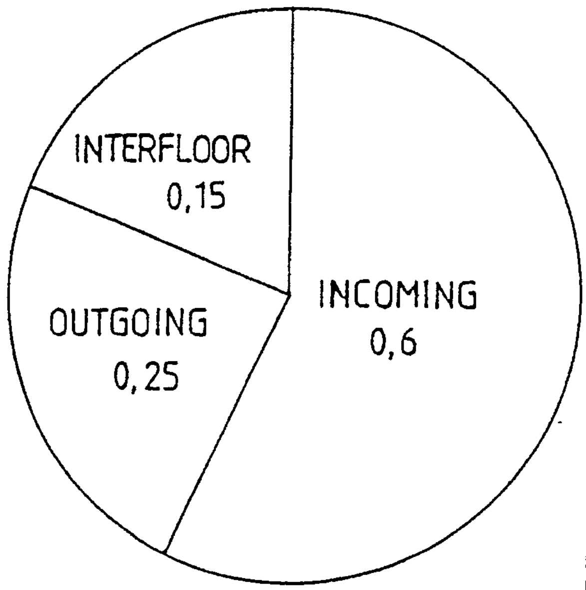

Fig.4

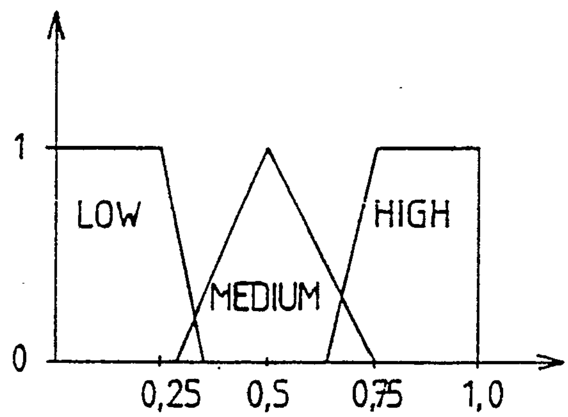

Fig.5

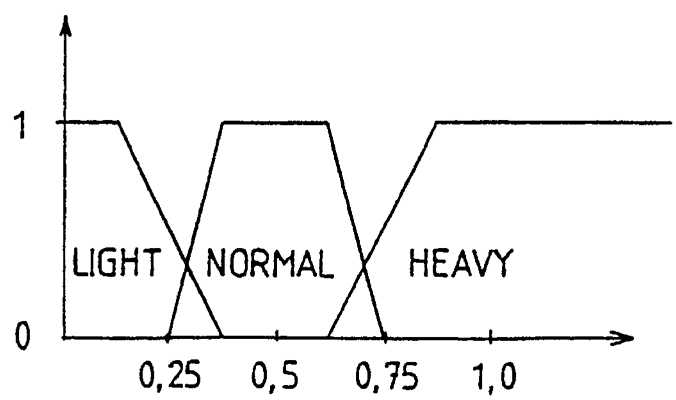

Fig.6